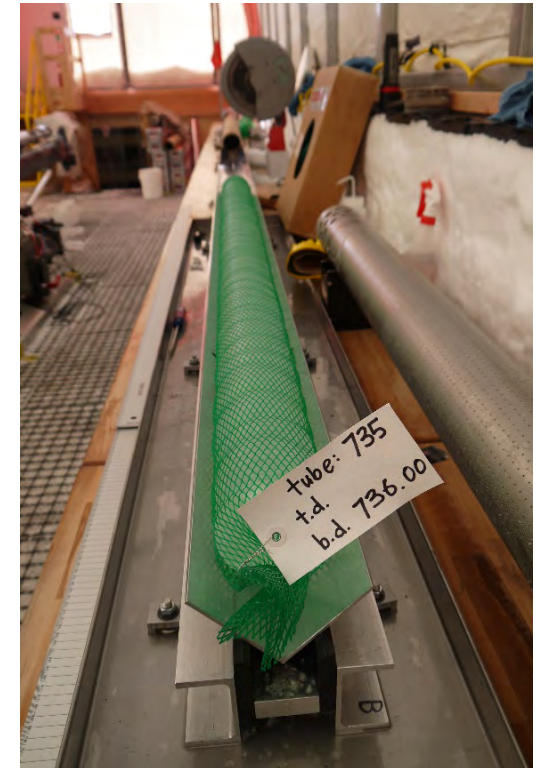
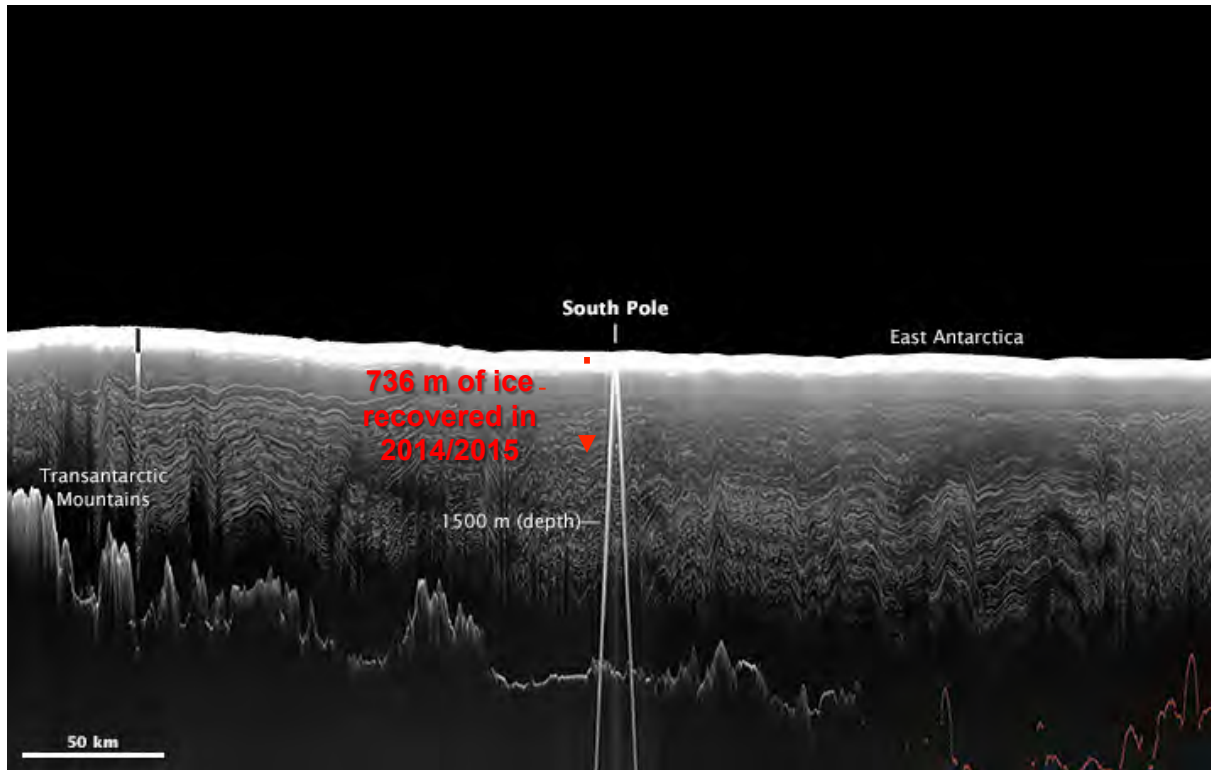
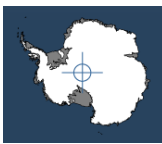




The South Pole ice core - Recovering a 40,000 year environmental record

Kimberly Casey, University of Maryland and Cryospheric Sciences, NASA GSFC,

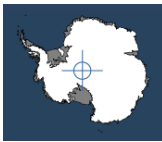
Thomas Neumann, Cryospheric Sciences, NASA GSFC



A new 1500 m ice core is being recovered from the South Pole (Casey et al., 2014). The 2014-2015 Austral season initiated drilling and successfully recovered 736 m of ice, exceeding first season project goals.



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References:

Casey, K.A., Fudge, T.J., Neumann, T.A., Steig, E.J., Cavitte, M.G.P. and Blankenship, D.D. (2014) The 1500 m South Pole ice core: recovering a 40,000 year environmental record, *Annals of Glaciology*, 55(68), p. 137 – 146, 10.3189/2014AoG68A016.

Earth Observatory, Image of the Day, 23 December, 2014, “What Lies Below”,
<http://earthobservatory.nasa.gov/IOTD/view.php?id=84947>

South Pole Ice Core (2014) <http://spicecore.org> Accessed April 30, 2015.

Data Sources: Operation Ice Bridge optical imagery of the South Pole region, airborne radar data, and ice sheet velocity maps were used within the project.

Technical Description of Figures:

Graphic 1: NASA scientists analyzed glaciologic stratigraphic and velocity data to help select a site for recovering the new 1500 m South Pole ice core. The image on the left of slide 1 displays airborne radar data acquired by the University of Texas Institute for Geophysics showing ice stratigraphy from the Transantarctic Mountains toward East Antarctica. Ice layering near the South pole is continuous and has minimal stratigraphic disturbances in the upper 1500 m of ice.

Graphic 2: The final ice core acquired in the 2014-2015 austral season reached just over 736 m in depth, equating to approximately 10,000 years before present. The second half of the ice core will be recovered over the 2015-2016 austral season.

Scientific significance, societal relevance, and relationships to future missions: The 1500m South Pole ice core, recovered using the newly developed US intermediate depth drill, will provide important climate and environmental records for the past 40,000 years. Due to the low temperatures, high accumulation rates and low impurity concentrations at South Pole, the chemistry and trace-gas records are expected to be well preserved in the core. The 1500m core will provide a high temporal resolution climate history of the connection and confluence of the West Antarctic moisture-laden air masses with the cold dry East Antarctic high-plateau air masses. The core will provide potential to investigate climate sensitivity and identify tropical teleconnections including El Niño signals.

The North Atlantic Ocean Heat Content (OHC) variability: Subtropical mode waters gaining heat while getting cooler - midthermocline isopycnals sinking!

Sirpa Häkkinen, Cryospheric Sciences, NASA GSFC; Peter B. Rhines, UW; Denise L. Worthen, Wyle STE GSFC

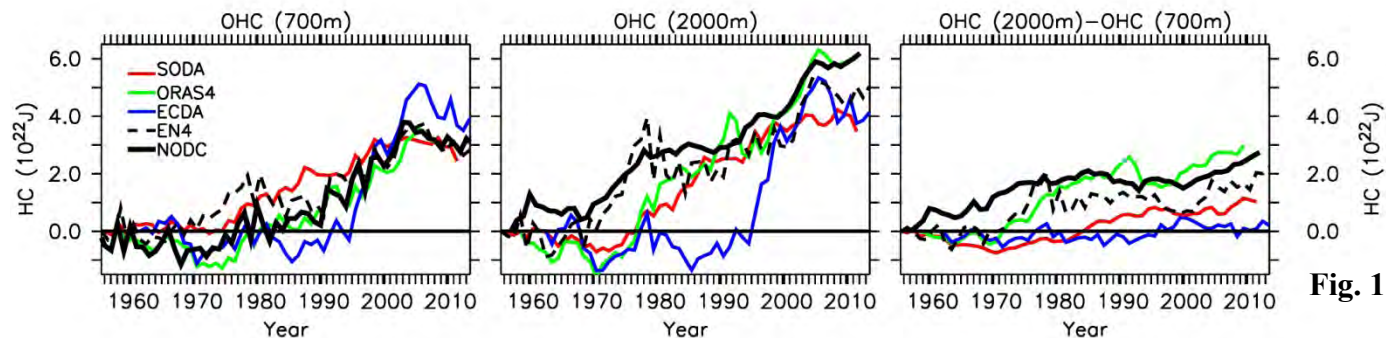


Fig. 1

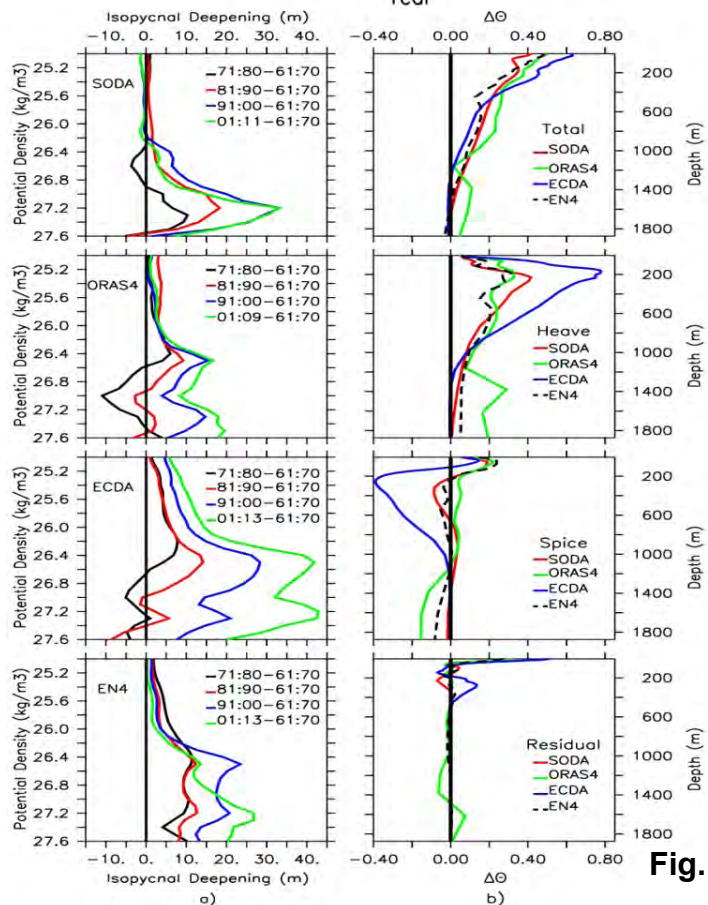


Fig. 2

Decomposition of ocean temperatures into sinking (heaving) of density surfaces and warming along the density surfaces (spice) in the N. Atlantic shows that warming is dominated by heaving of density surfaces at midthermocline (200-800m). This causes expansion of subtropical mode water volume from the 1960s to 2000s. Those mode waters have actually cooled slightly, seen in water mass change along the density surface ('Spice') component of temperature.



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References:

Häkkinen, S., P. B. Rhines, and D. L. Worthen (2015), Heat content variability in the North Atlantic Ocean in ocean reanalyses, *Geophysical Research Letters*, 42, doi:10.1002/2015GL063299.

Data Sources: Study two observational data sets (NOAA/NODC heat content, Hadley Center optimally interpolated salinity and temperature data set) and three ocean state reanalyses (SODA, ECMWF/ORAS4, NOAA/GDFL/ECDA).

Technical Description of Figures:

Fig. 1. Evolution of the North Atlantic (0-65°N) heat content anomaly integrated over upper 700m, 2000m and their difference for the reanalyses SODA, ORAS4, ECDA, and data reconstructions EN4 and NODC. Colors denote different data sets labeled in the left figure. All are referenced to the first year of the record. Units are 10^{22} J.

Fig. 2. (a) Area average vertical migration of isopycnals in SODA, ORAS4, ECDA, and objectively analyzed data, EN4, in the North Atlantic in meters as decadal averages referenced to 1961-1970, positive values denote deepening, negative shoaling. (b) Potential temperature change [1995-2009] minus [1961-1975] versus depth in the same data sets: the total change, due to heaving and due to water mass change (spice), and residual, in units of Celsius.

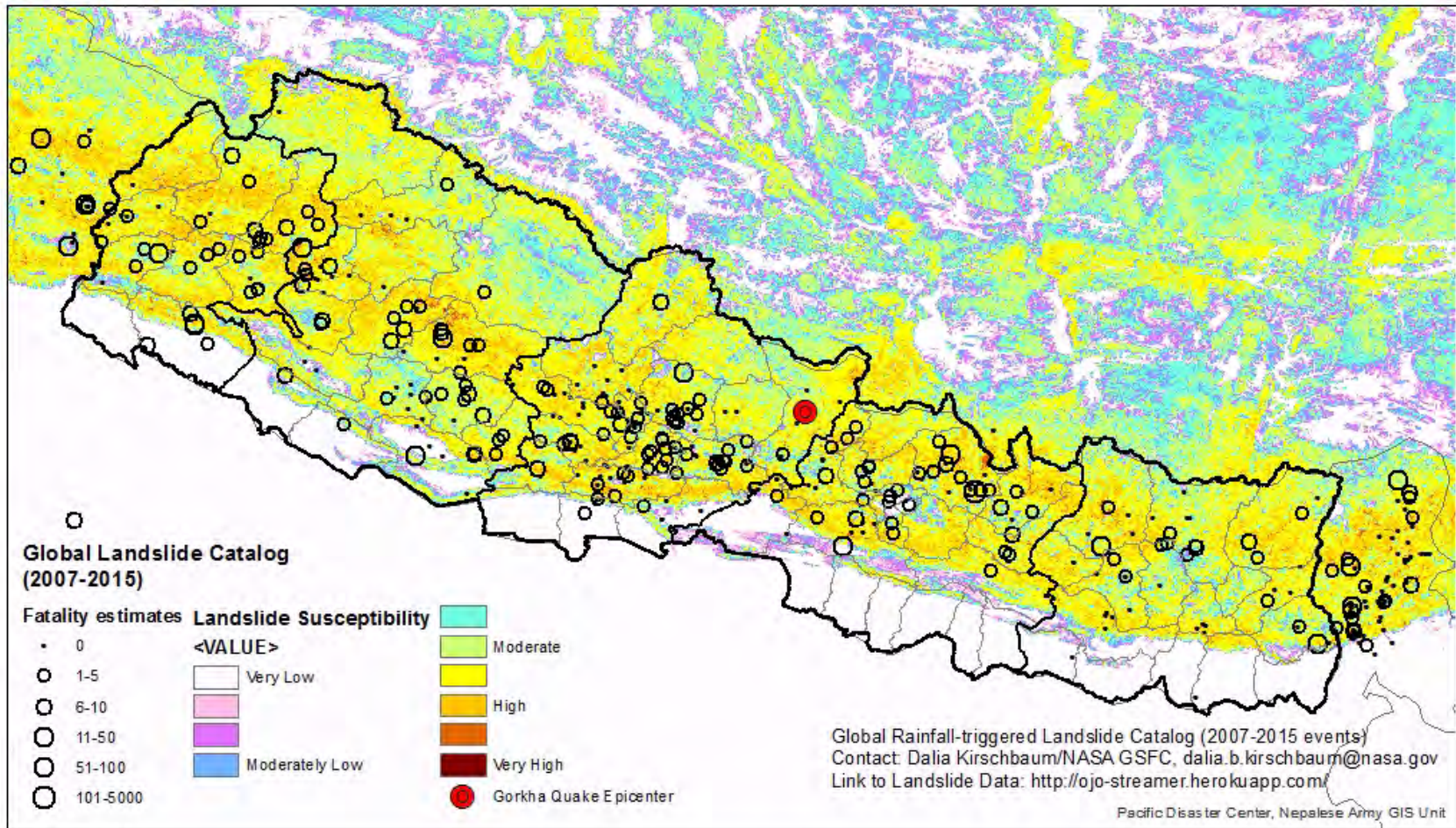
Scientific significance, societal relevance, and relationships to future missions: Recent studies have argued for the increased uptake of the deep ocean. In the case of North Atlantic Ocean we do not see the ocean below the thermocline taking up an appreciable amount of heat, on the contrary, most heat has accumulated to the subtropical mode water layer, at the expense of the subpolar mode waters. The increased heat content of the subtropical mode waters appears as sinking of their isopycnals, i.e. they are increasing their volume. Warming of the North Atlantic Ocean from the 1950s to 2012 is analyzed on neutral density surfaces and vertical levels in the upper 2000 meters. Three reanalysis and two observational datasets are compared. Upper ocean heat content (OHC) is dominated in most regions by heat transport convergence (heaving of isopycnals) without widespread changes in the potential temperature/salinity relation. The heat convergence is associated with sinking of mid-thermocline isopycnals, with maximum sinking occurring at potential densities $\sigma_0 = 26.4$ -27.3, which contain subtropical mode waters. Water masses lighter than $\sigma_0 = 27.3$ accumulate heat by increasing their volume, while heavier waters lose heat by decreasing their volume. Spatially the OHC trend is non-uniform: The low latitudes, 0-30°N are warming steadily while large multi-decadal variability occurs at latitudes 30-65°N.

Ocean heat content is reflected in satellite sea surface height measurements. In our follow-up work we will show that decomposition of OHC into heaving (temperature changes due to heaving of isopycnals) and spice (temperature changes along isopycnals) components is an effective way to separate dynamic and thermodynamic effects in sea surface height variability.



Regional Landslide Susceptibility Map (Pre-earthquake estimates)

Dalia Kirschbaum and Thomas Stanley, Hydrological Sciences, NASA GSFC



Date: 5/1/2015

Landslides are pervasive in the Himalayan arc as a result of active tectonics, monsoon rainfall and human impact. This preliminary map represents landslide susceptibility for the region, calculated from slope, road networks, fault zones and bedrock types, and forest loss. This map is overlaid with the Global Landslide Catalog, highlighting rainfall-triggered landslides from 2007-2015.



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References:

Kirschbaum, D.B., Stanley, T., Zhou, Y., 2015. Spatial and Temporal Analysis of a Global Landslide Catalog. *Geomorphology*. doi:10.1016/j.geomorph.2015.03.016

Kirschbaum, D.B., Stanley, T., Yatheendradas, S., 2015. Modeling Landslide Susceptibility over Large Regions with Fuzzy Overlay. *Landslides*. doi:10.1007/s10346-015-0577-2

Data Sources: roads from OpenStreetMap, faults and bedrock types from the Geologic Map of the World (3rd Edition), Forest Loss from the University of Maryland's Global Forest Change study, and maximum slope values from the Global Slope Dataset produced by the USGS

Technical Description of Images:

Susceptibility map: This preliminary map was created to represent landslide susceptibility at a resolution of one kilometer. The map was created from four sources: roads from OpenStreetMap, faults and bedrock types from the Geologic Map of the World (3rd Edition), Forest Loss from the University of Maryland's Global Forest Change study, and maximum slope values from the Global Slope Dataset produced by the USGS. The landslide susceptibility map represents the possibility of a landslide's occurrence within each square kilometer of Nepal and is calculated using a fuzzy overlay methodology. This map can be used for regional situational awareness of potentially susceptible regions to landsliding across the country and region. This map does not identify ice and snow avalanche susceptibility.

Global Landslide Catalog: The Global Landslide Catalog (GLC) was developed with the goal of identifying rainfall-triggered landslide events around the world, regardless of size, impacts or location. The GLC considers all types of mass movements triggered by rainfall, which have been reported in the media, disaster databases, scientific reports, or other sources. The GLC has been compiled since 2007 at NASA Goddard Space Flight Center.

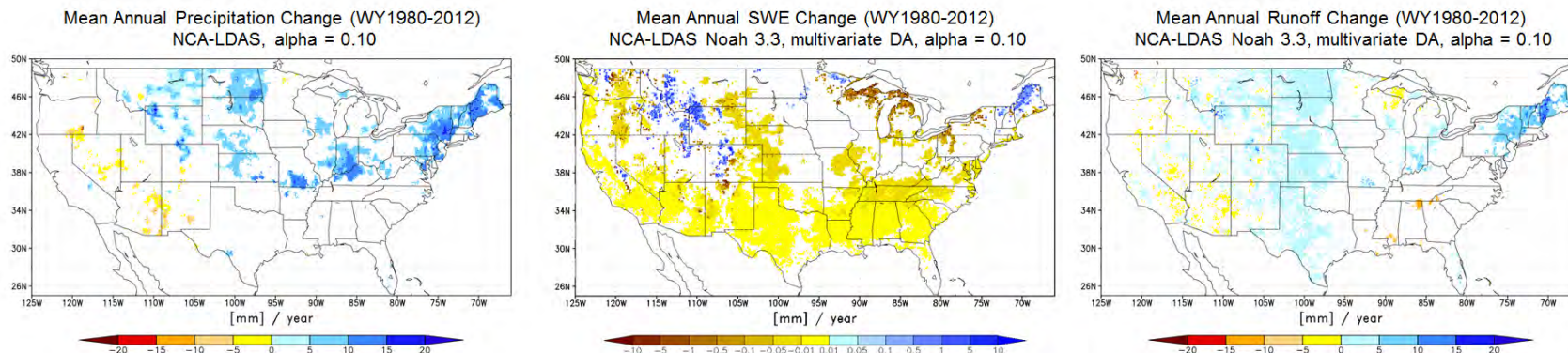
Scientific Significance: While regional monitoring systems for hurricanes, extreme precipitation, and earthquakes exist, there currently is not an operational system for near real-time assessment of hazards in this region. Here we present a susceptibility map that is designed for use in a dynamic model of rainfall-triggered landslides for the whole of South Asia and may be less predictive of landslides caused by other events, such as earthquakes. The goal of this system is to identify potentially susceptible areas to landslides in near real-time using precipitation inputs, surface conditions and antecedent rainfall. This system is currently in development and GPM IMERG data will be used for this dynamic system.

Relevance for future science and relationship to Decadal Survey: Precipitation information from Global Precipitation Measurement (GPM) mission (www.gpm.nasa.gov) helps to relate static landslide susceptibility information ("where" landslides may occur) to precipitation triggers ("when" landslides may be triggered), which is particularly important when determining conditions during the monsoon season.

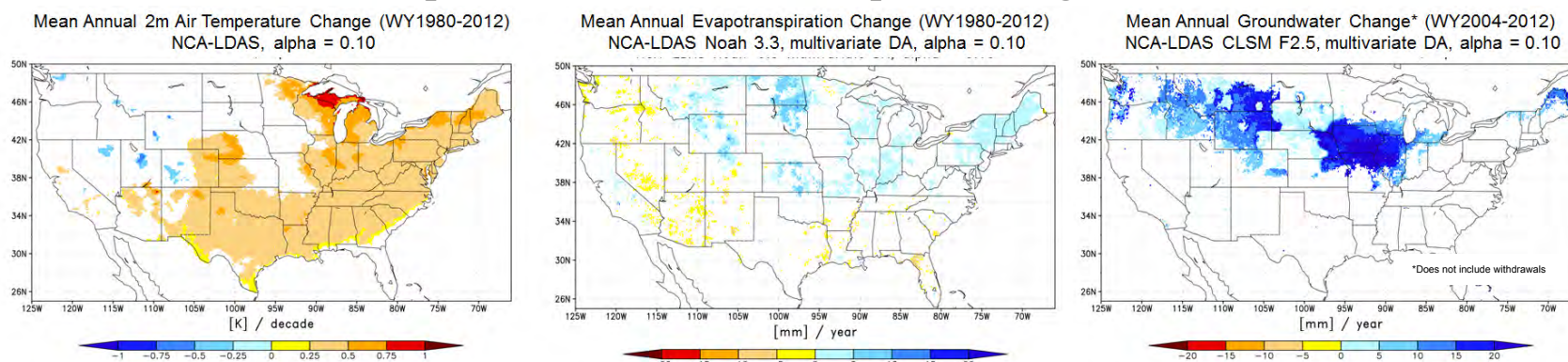


NCA-LDAS: An Integrated Terrestrial Water Analysis System for Evaluation and Dissemination of National Climate Assessment (NCA) Indicators

Michael Jasinski, Hydrological Sciences Lab, NASA GSFC
K. Arsenault, H. Beaudoin, J. Bolten, J. Borak, S. Kempler, S. Kumar,
C. Peters-Lidard, B. Li, Y. Liu, D. Mocko, M. Rodell and B. Vollmer



Sample Water Indicators Computed Using NCA-LDAS



NCA-LDAS is being created as an end-to-end enabling tool for sustained evaluation and dissemination of terrestrial hydrologic indicators. Recent progress includes completion of a multivariate satellite data assimilation capability within the Land Information System and development of preliminary water indicators focusing on climate change during the satellite era (1979-present). Public access to all NCA-LDAS products will be provided through the NASA GES DISC.



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Recent References:

- Kumar, S.V., B. Zaitchik, C. Peters-Lidard, M. Rodell, R. Reichle, B. Li, M. Jasinski, D. Mocko, A. Getirana, G. DeLannoy, M. Cosh, C. Hain, M. Anderson, "Assimilation of gridded GRACE terrestrial water storage estimates in the North American Land Assimilation System", submitted to *Water Resources Research*, Feb 2015.
- Kumar, S., C. Peters-Lidard, J. Santanello, C. Draper, R. Koster, G. Nearing, M. Jasinski, "Evaluating the utility of satellite soil moisture retrievals over irrigated areas and the ability of land data assimilation methods to correct for unmodeled processes", submitted to *Hydrol. Earth Syst. Sci.*, April 2015.

Data Sources: The National Climate Assessment Land Data Assimilation System (NCA-LDAS) employs a multivariate data assimilation approach ingesting the following products (Satellite data product; sensor(s); spatial resolution; assimilation period; reference):

1. Snow covered area: Terra/Aqua MODIS; 500m; 2000-13; Hall et al., 2002; Brown and Robinson, 2011; Robinson et al., 2012.
2. Snow covered area: AVHRR, GOES, passive microwave; 24-km; 1997-present; Ramsay 1998.
3. Snow depth/SWE: SMMR, SSM/I, Aqua AMSR-E; 25-km; 1979-present; Kelly et al., 2004.
4. Terrestrial water store: GRACE; 500-km; 2003-present; Landerer and Swenson, 2012.
5. Soil moisture: SMMR, SSM/I, TMI, Aqua AMSR-E, ASCAT; 25-km; 1979-present(ASCAT-2007-present); de Jeu, 2003, Njoku, 2007, Gao et al. 2006, Li et al. 2010, Liu et al. 2012, Wagner et al. 2012.
6. Irrigated area: Terra/Aqua MODIS; 1km; 2000-present; Ozdogan et al., 2010.

Technical Description of Figures: NCA-LDAS is being created as an end-to-end enabling tool for sustained evaluation and dissemination of terrestrial hydrologic indicators in support of the NCA. The project's three principal components are:

- i) Building a multivariate satellite data assimilation (DA) capability within the Land Information System (LIS) framework with the goal of improving the accuracy of modeled hydrologic time series over the US domain.
- ii) Developing and evaluating NCA water indicators, focusing on trends during the satellite era (~1979-present), using output generated within NCA-LDAS. Over 60+ output variables are available for analyses.
- iii) Providing public access to all NCA-LDAS generated products, including input/output fields and trend analyses, through the NASA GES DISC and Giovanni systems.

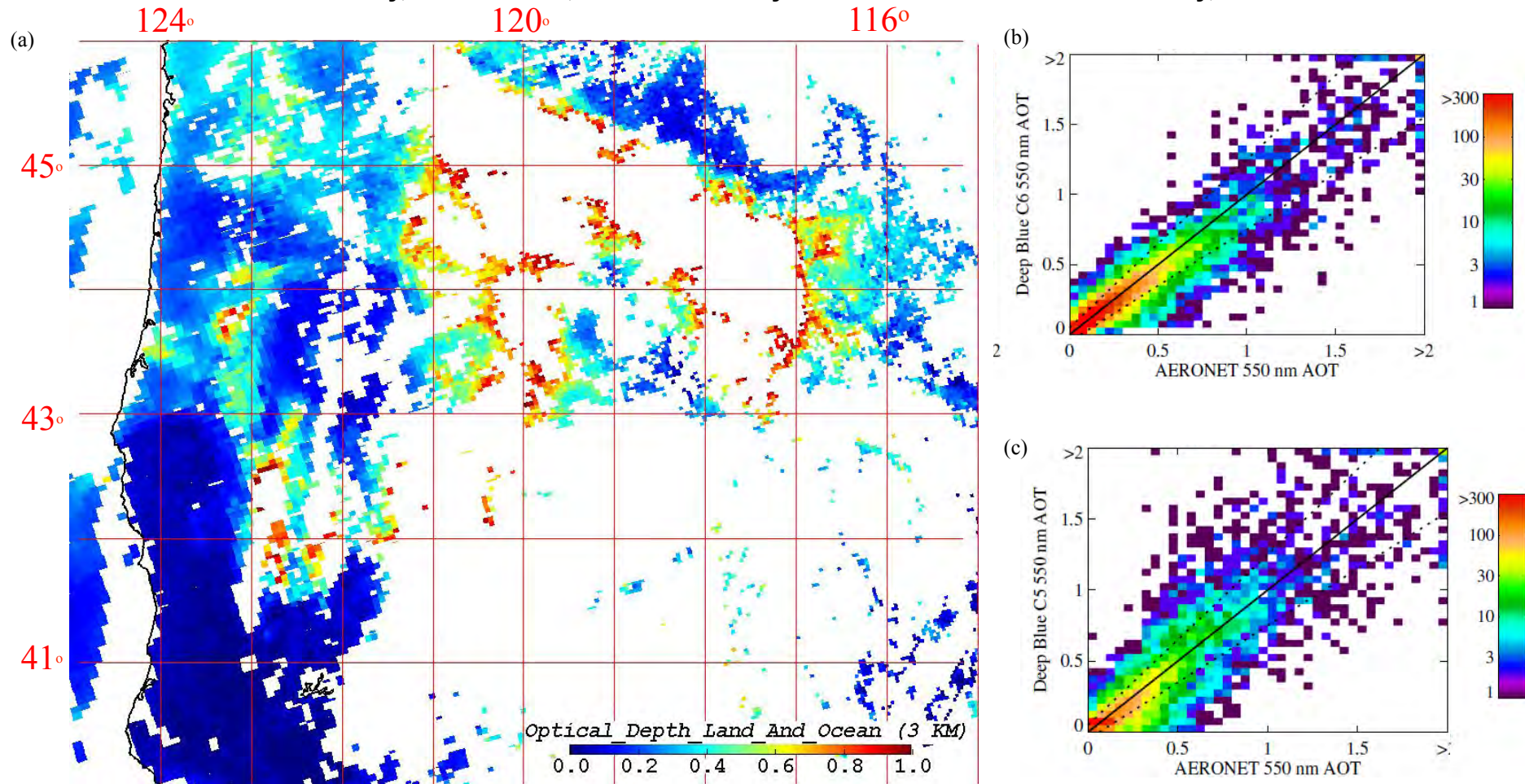
Sample trends for six indicators from the current 35-yr simulation of NCA-LDAS are shown in the figure. Trends in NCA-LDAS input indicators show increasing precipitation in the North Central and Northeast US, and increasing temperature in the East and South Central US. Sample indicators from NCA-LDAS output include mean annual runoff, mean annual evapotranspiration, mean annual snow water equivalent and mean annual groundwater storage. While trends are computed at all model grid-boxes, only those passing the Mann - Kendall Test at 0.10 alpha level are reported. Initial results were presented by the PI at the AGU Fall 2014 Meeting.

Scientific significance, societal relevance, and relationships to future missions: Numerous national and regional planning efforts are being made across a wide sector of disciplines, including climate science, agriculture, water resource, ecosystems, health, etc., in response to the anticipated future changes reported in the National Climate Assessment. Currently, nearly all NCA forecasts rely in situ data, and they are thus limited to the availability and density of gages. The goal of NCA-LDAS is to employ NASA's observation and modeling D/A capability to provide improved temporal and spatial trend analysis that sparse in situ data can not provide, and provide these freely to the public, to support their decision making. Assimilation of new satellite records from GPM, SMAP, AMSR-2 etc., are being planned for sustained analyses.



MODIS Atmosphere Products offer Improved Quality, Coverage and Resolution

Edward Masuoka, Terrestrial Information Systems, NASA GSFC, Dr. Christina Hsu, Climate and Radiation Laboratory, NASA GSFC, and Robert Levy Climate and Radiation Laboratory, NASA GSFC



The C6 reprocessing of MODIS atmosphere products resulted in significant improvements to their utility. Aerosol retrievals, for example, were extended to higher latitudes over oceans and from deserts to vegetated surfaces and a 3km resolution product (a) was added to support air quality studies. Comparison of aerosol products with ground measurements found the new products (b) had improved agreement with AERONET sites over those from the previous C5 reprocessing (c).



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Abstract:

The MODIS Adaptive Processing System (MODAPS) has completed the "Collection 6" reprocessing of MODIS Atmospheric products for both Terra and Aqua missions. New aerosol and cloud products result from an extensive Science Team development process leveraging numerous validation studies.

This report focuses on aerosols. Aerosol parameters are the product of three distinct retrieval methods dictated by surface type, namely, the Dark Target (DT) ocean method, the DT land method and the Deep Blue (DB) bright surface method. All methods are highly sensitive to sensor spectral calibration and scan angle, thus requiring challenging calibration approaches (i.e., surface target trends, cross-platform studies, polarization corrections). Product quality improvements have come from these improved sensor calibration methods, plus more detailed and accurate surface and aerosol scattering models and better cloud filtering. Quality estimates, which are imbedded in each Level-2 product file, are critical to deriving statistically-averaged Level-3 global products at one degree spatial resolution.

Aerosol retrieval coverage is now larger. The Deep Blue algorithm successfully extended its coverage (bright desert scenes only in the prior release) by adding vegetated surfaces in Collection 6, thus allowing direct inter-comparison of DB and DT retrievals in many regions. A combined product reports aerosol optical depth from the best quality method in addition to separate estimates. Additionally, DT ocean retrievals are now included for higher latitude regions, while DT retrievals can now be done over inland lakes.

References:

Levy, R. C., Mattoo, S., Munchak, L. A., Remer, L. A., Sayer, A. M., Patadia, F., and Hsu, N. C., "The Collection 6 MODIS aerosol products over land and ocean", *Atmos. Meas. Tech.*, 6, 2989-3034, doi:10.5194/amt-6-2989-2013, 2013.

Hsu, N. C., M.-J. Jeong, C. Bettenhausen, A. M. Sayer, R. Hansell, C. S. Seftor, J. Huang, and S.-C. Tsay (2013), Enhanced Deep Blue aerosol retrieval algorithm: The second generation, *J. Geophys. Res. Atmos.*, 118, 9296–9315, doi:10.1002/jgrd.50712

Sayer, A. M., N. C. Hsu, C. Bettenhausen, and M.-J. Jeong (2013), Validation and uncertainty estimates for MODIS Collection 6 "Deep Blue" aerosol data, *J. Geophys. Res. Atmos.*, 118, 7864–7872, doi:10.1002/jgrd.50600

Data Sources: MODIS Collection 6 aerosol and cloud products are available for Aqua and Terra missions via LAADS (<http://ladsweb.nascom.nasa.gov>).

Technical Description of Figures:

Figure a: This image illustrates DT 3KM optical depth results while fires were present in the US Northwest. High aerosols are red, orange and yellow.

Figures b and c: Validation against AERONET demonstrates that C6 DB results have reduced scatter and continue to show very little systematic bias.

Scientific significance:

Validated satellite aerosol measurements having daily global coverage (together with transport models) are critical to assessing both natural and human impacts on regional air quality and regional-to-global change. The data are also key to process studies of aerosol-cloud interactions.

Relevance for future science and relationship to Decadal Survey:

The MODIS atmosphere products are critical to understand our changing planet. Most will be continued by instruments such as VIIRS, the Visible Infrared Imaging Radiometer Suite, that will extend their data record for decades to come.